

Project Time Management

Learning Objectives

- Understand the importance of project schedules and good project time management.
- Define activities as the basis for developing project schedules.
- Describe how project managers use network diagrams and dependencies to assist in activity sequencing.
- Understand the relationship between estimating resources and project schedules.
- Explain how various tools and techniques help project managers perform activity duration estimating.

Learning Objectives

- Use a Gantt chart for planning and tracking schedule information, find the critical path for a project, and describe how critical chain scheduling and the Program Evaluation and Review Technique (PERT) affect schedule development.
- Discuss how reality checks and people issues are involved in controlling and managing changes to the project schedule.
- Describe how project management software can assist in project time management and review words of caution before using this software.

Developing the Project Plan

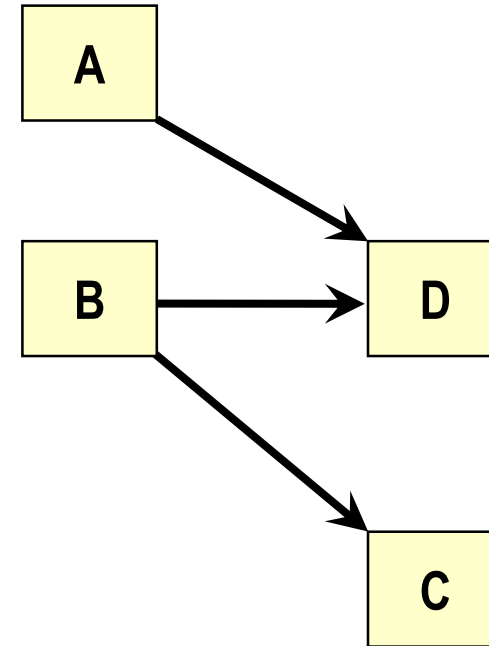
- The Project Network
 - A flow chart that graphically depicts the sequence, interdependencies, and start and finish times of the project job plan of activities that is the *critical path* through the network.
 - Provides the basis for scheduling labor and equipment.
 - Enhances communication among project participants.
 - Provides an estimate of the project's duration.
 - Provides a basis for budgeting cash flow.
 - Identifies activities that are critical.
 - Highlights activities that are “critical” and can not be delayed.
 - Help managers get and stay on plan.

Project Time Management Processes

- **Activity definition:** Identifying the specific activities that the project team members and stakeholders must perform to produce the project deliverables.
- **Activity sequencing:** Identifying and documenting the relationships between project activities.
- **Activity resource estimating:** Estimating how many resources a project team should use to perform project activities.
- **Activity duration estimating:** Estimating the number of work periods that are needed to complete individual activities.
- **Schedule development:** Analyzing activity sequences, activity resource estimates, and activity duration estimates to create the project schedule.
- **Schedule control:** Controlling and managing changes to the project schedule.

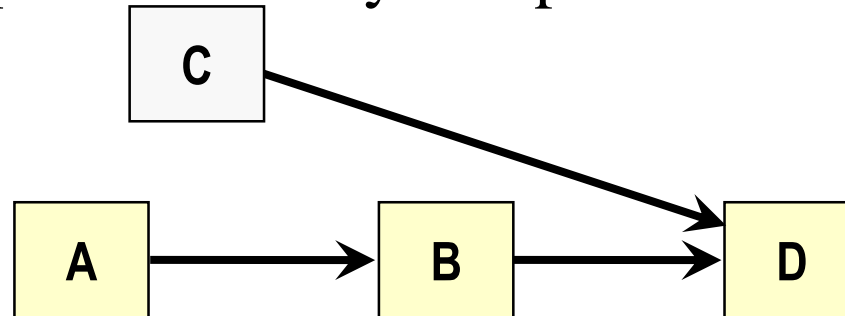
Constructing a Project Network

- Terminology
 - **Activity:** an element of the project that requires time.
 - **Merge Activity:** an activity that has two or more preceding activities on which it depends.
 - **Parallel (Concurrent) Activities:** Activities that can occur independently and, if desired, not at the same time.



Constructing a Project Network

- Terminology (cont'd)
 - **Path:** a sequence of connected, dependent activities.
 - **Critical path:** the longest path through the activity network that allows for the completion of all project-related activities; the shortest expected time in which the entire project can be completed. Delays on the critical path will delay completion of the entire project.

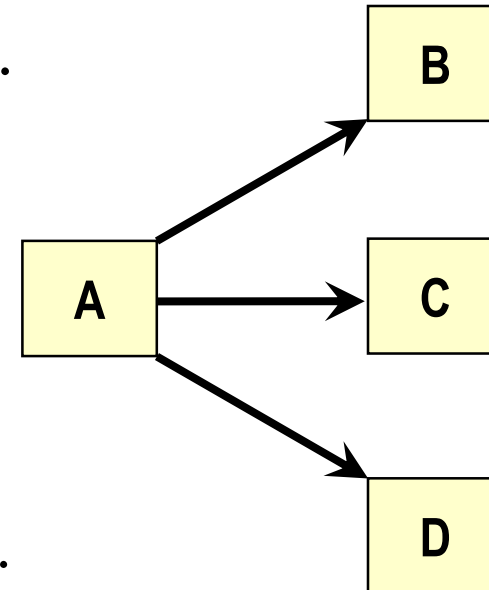


(Assumes that minimum of A + B > minimum of C in length of times to complete activities.)

Constructing a Project Network

- Terminology (cont'd)
 - **Event:** a point in time when an activity is started or completed. It does not consume time.
 - **Burst Activity:** an activity that has more than one activity immediately following it (more than one dependency arrow flowing from it).

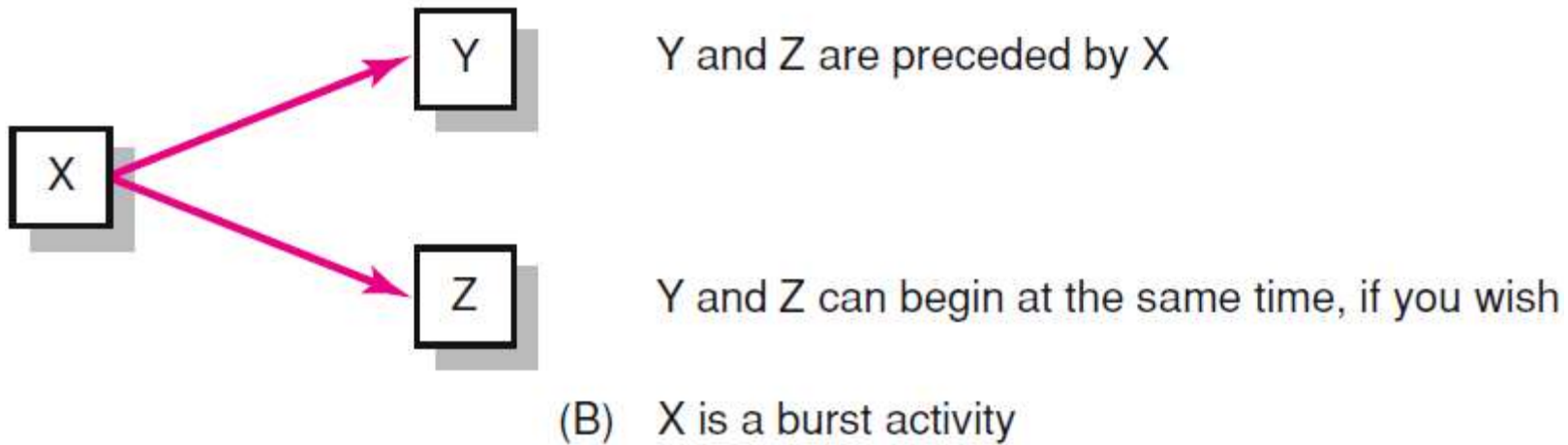
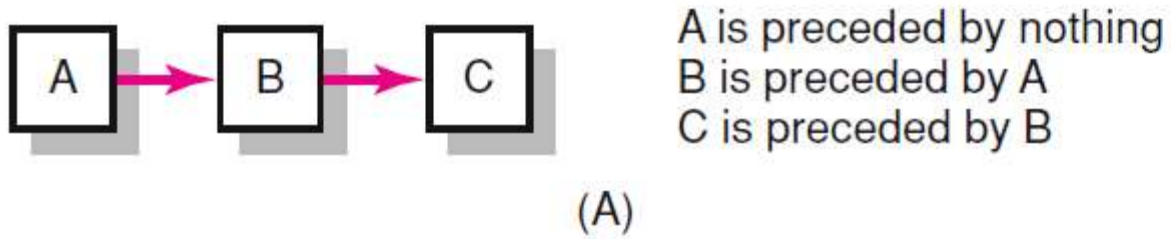
- Two Approaches
 - Activity-on-Node (AON)
 - Uses a node to depict an activity.
 - Activity-on-Arrow (AOA)
 - Uses an arrow to depict an activity.



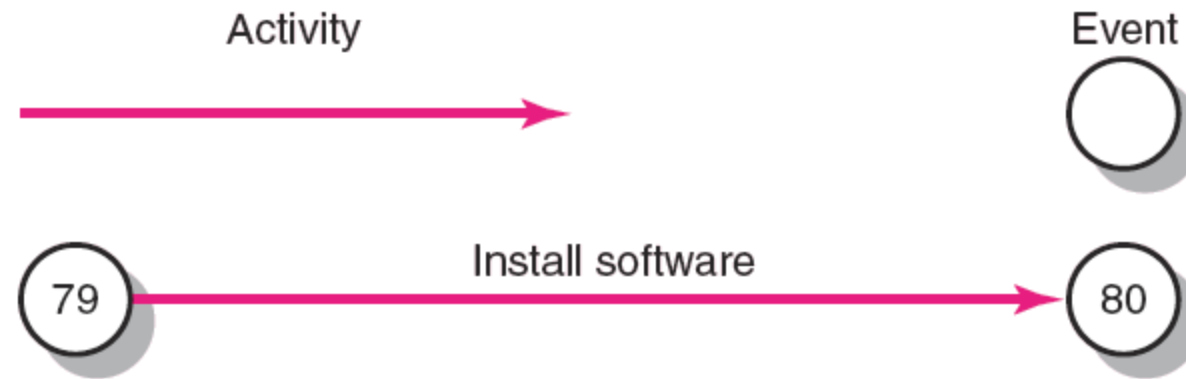
Basic Rules to Follow in Developing Project Networks

1. Networks typically flow from left to right.
2. An activity cannot begin until all preceding connected activities are complete.
3. Arrows indicate precedence and flow and can cross over each other.
4. Each activity must have a unique identify number that is greater than any of its predecessor activities.
5. Looping is not allowed.
6. Conditional statements are not allowed.
7. Use common start and stop nodes.

Activity-on-Node Fundamentals



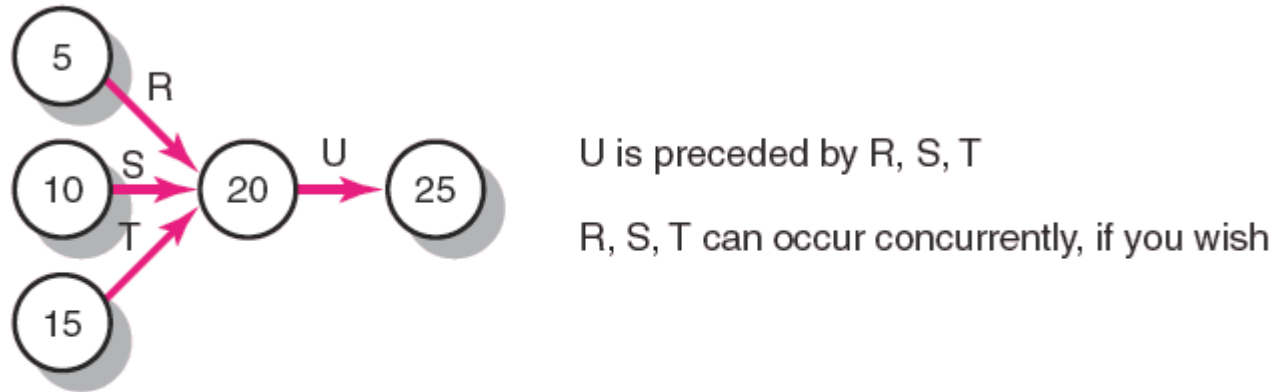
Activity-on-Arrow Network Building Blocks



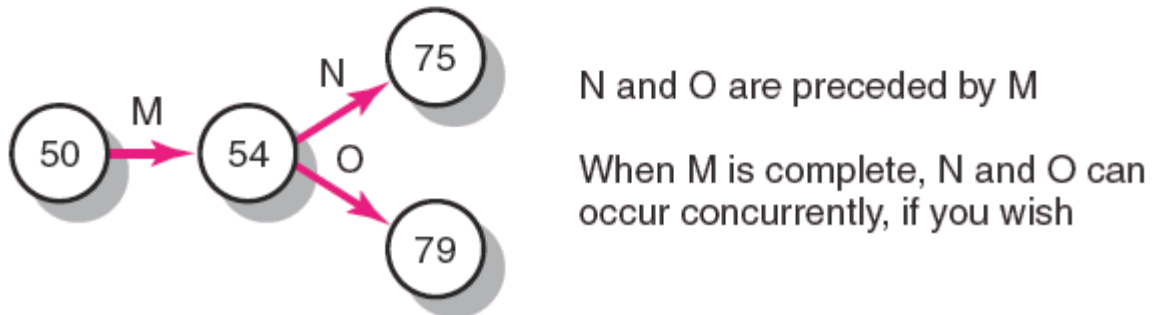
Activity-on-Arrow Network Fundamentals



(A)



(B)



(C)

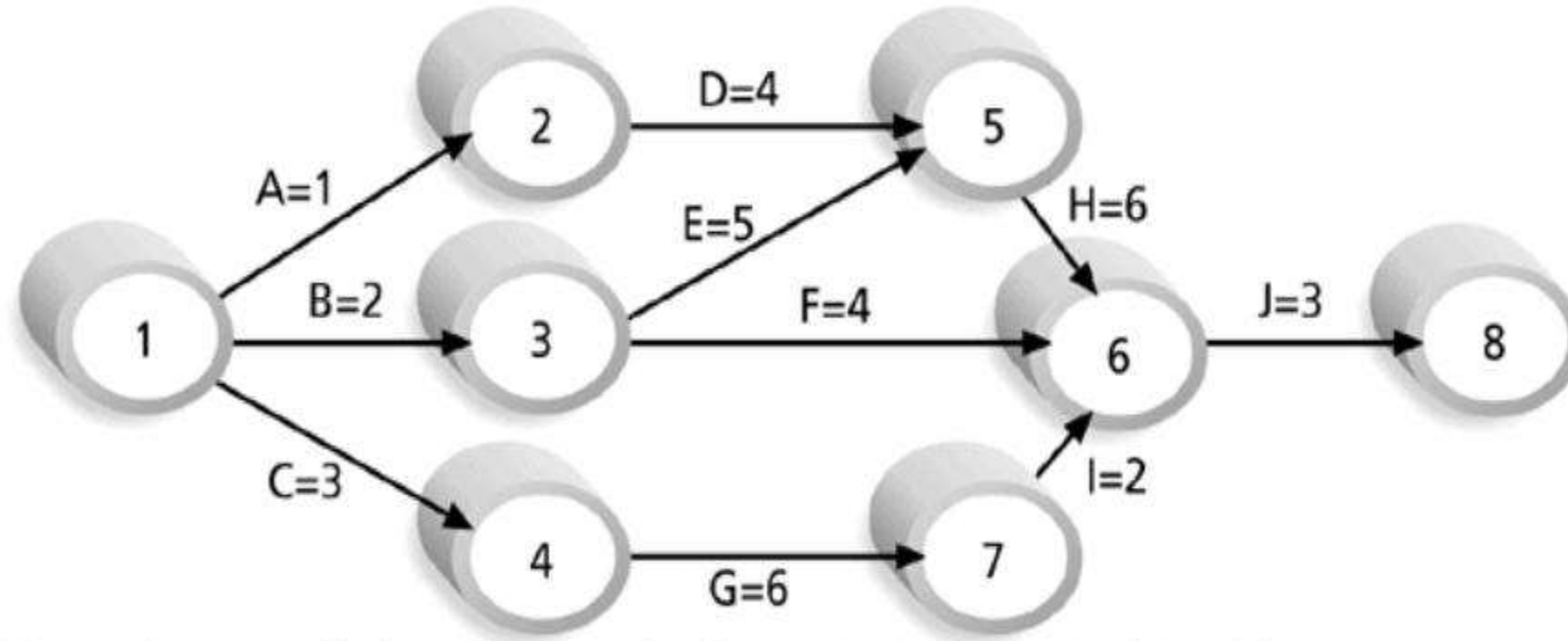
Network Diagrams

- Network diagrams are the preferred technique for showing activity sequencing.
- A **network diagram** is a schematic display of the logical relationships among, or sequencing of, project activities.
- Two main formats are the arrow and precedence diagramming methods.

Example

Activity	Preceding Activity	Duration
A	-	1
B	-	2
C	-	3
D	A	4
E	B	5
F	B	4
G	C	6
H	D, E	6
I	G	2
J	F, H, I	3

Sample Activity-on-Arrow (AOA) Network Diagram for Project X

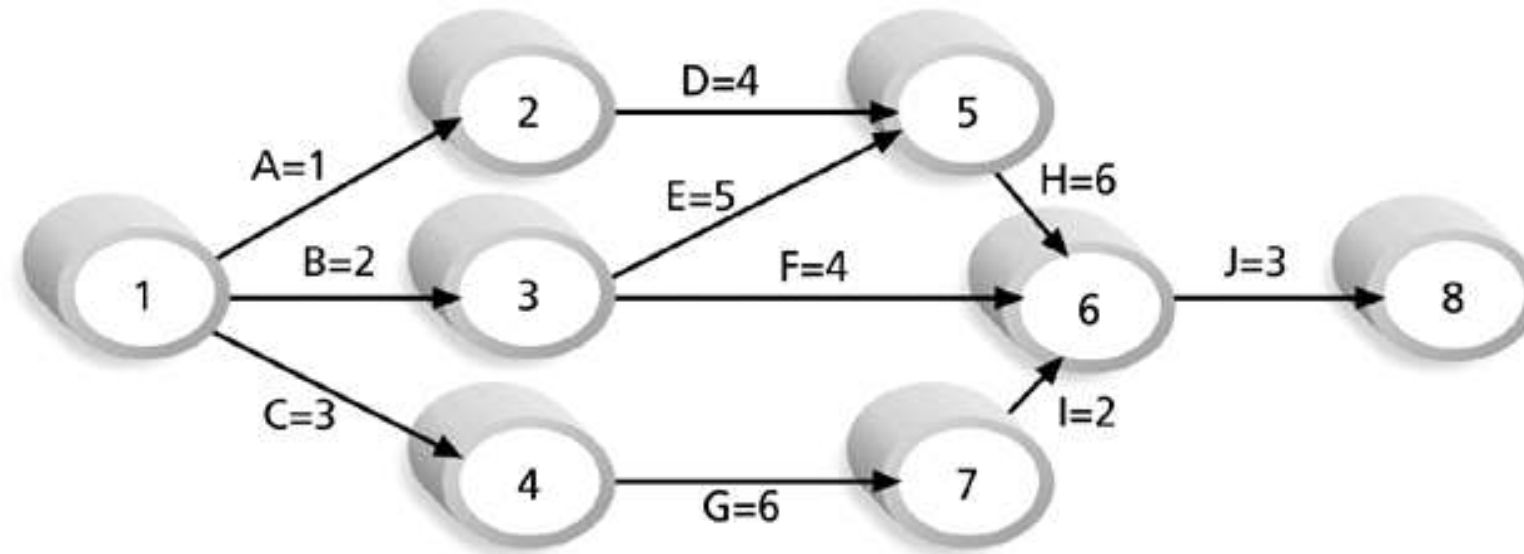


Note: Assume all durations are in days; A=1 means Activity A has a duration of 1 day.

Critical Path Method (CPM)

- **CPM** is a network diagramming technique used to predict total project duration.
- A **critical path** for a project is the series of activities that determines the *earliest time* by which the project can be completed.
- The critical path is the *longest path* through the network diagram and has the least amount of slack or float.
- **Slack** or **float** is the amount of time an activity can be delayed without delaying a succeeding activity or the project finish date.

Determining the Critical Path for Project X



Note: Assume all durations are in days.

Path 1: A-D-H-J Length = $1+4+6+3 = 14$ days

Path 2: B-E-H-J Length = $2+5+6+3 = 16$ days

Path 3: B-F-J Length = $2+4+3 = 9$ days

Path 4: C-G-I-J Length = $3+6+2+3 = 14$ days

Since the critical path is the longest path through the network diagram, Path 2, B-E-H-J, is the critical path for Project X.

Using Critical Path Analysis to Make Schedule Trade-offs

- A **forward pass** through the network diagram determines the earliest start and finish dates.
- A **backward pass** determines the latest start and finish dates.
- **Float or Slack** is the amount of time that an activity can delay without delaying the project

$$\text{Slack for Task } i = LS_i - ES_i \text{ or } LF_i - EF_i$$

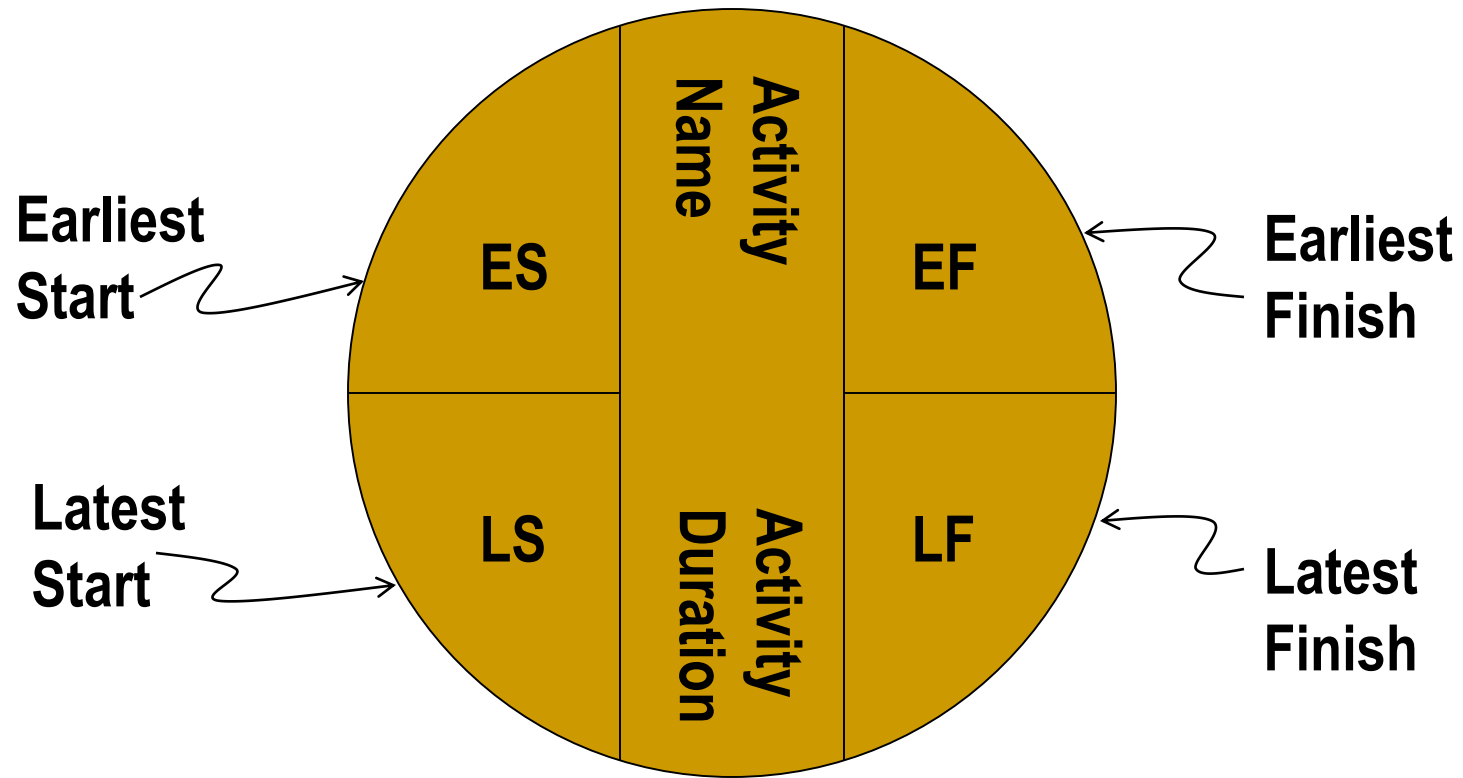
Earliest Start and Finish Steps

- Begin at starting event and work forward
- $ES = 0$ for starting activities
 - ES is earliest start
- $EF = ES + \text{Activity time}$
 - EF is earliest finish
- $ES = \text{Maximum } \{EF \text{ of all immediate predecessors}\}$

Latest Start and Finish Steps

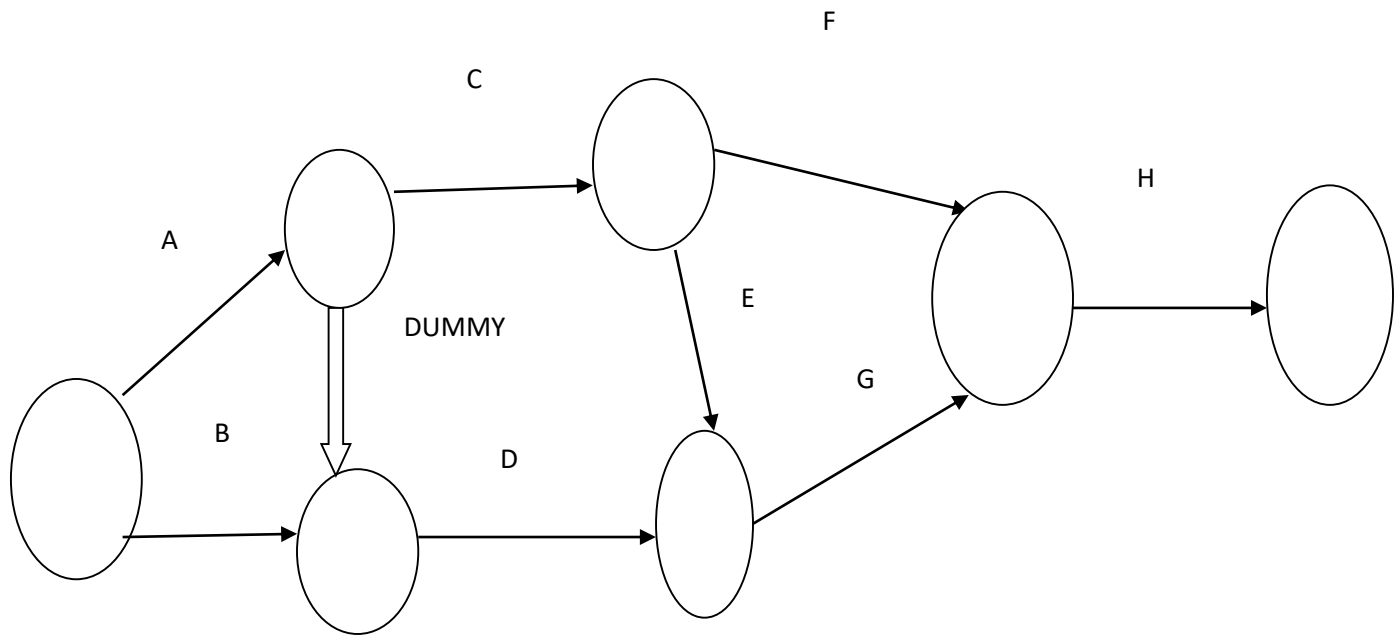
- Begin at ending event and work backward
- $LF = \text{Maximum EF for ending activities}$
 - LF is latest finish; EF is earliest finish
- $LS = LF - \text{Activity time}$
 - LS is latest start
- $LF = \text{Minimum \{LS of all immediate successors\}}$

Latest Start and Finish Steps

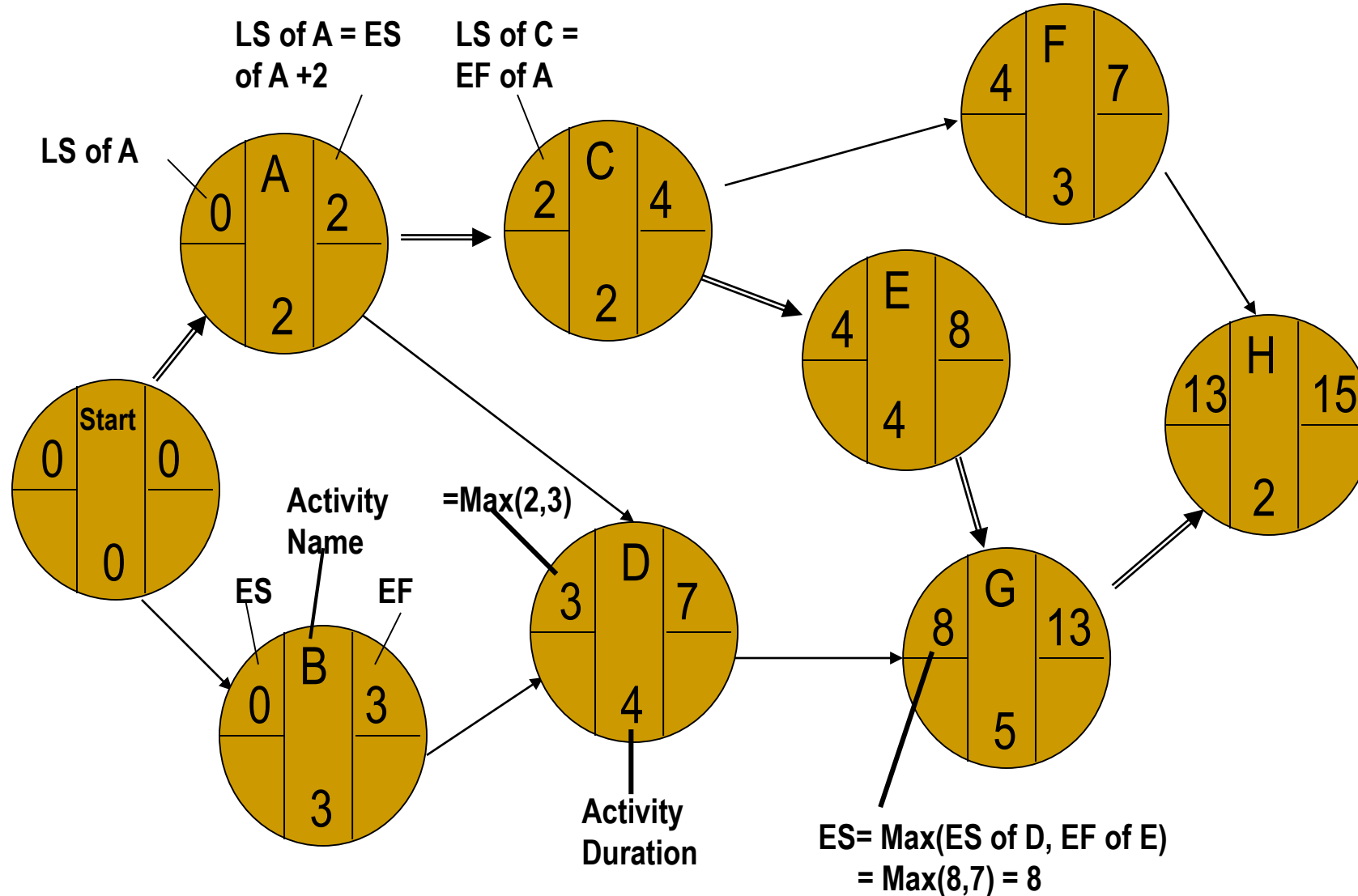


Activities and Predecessors

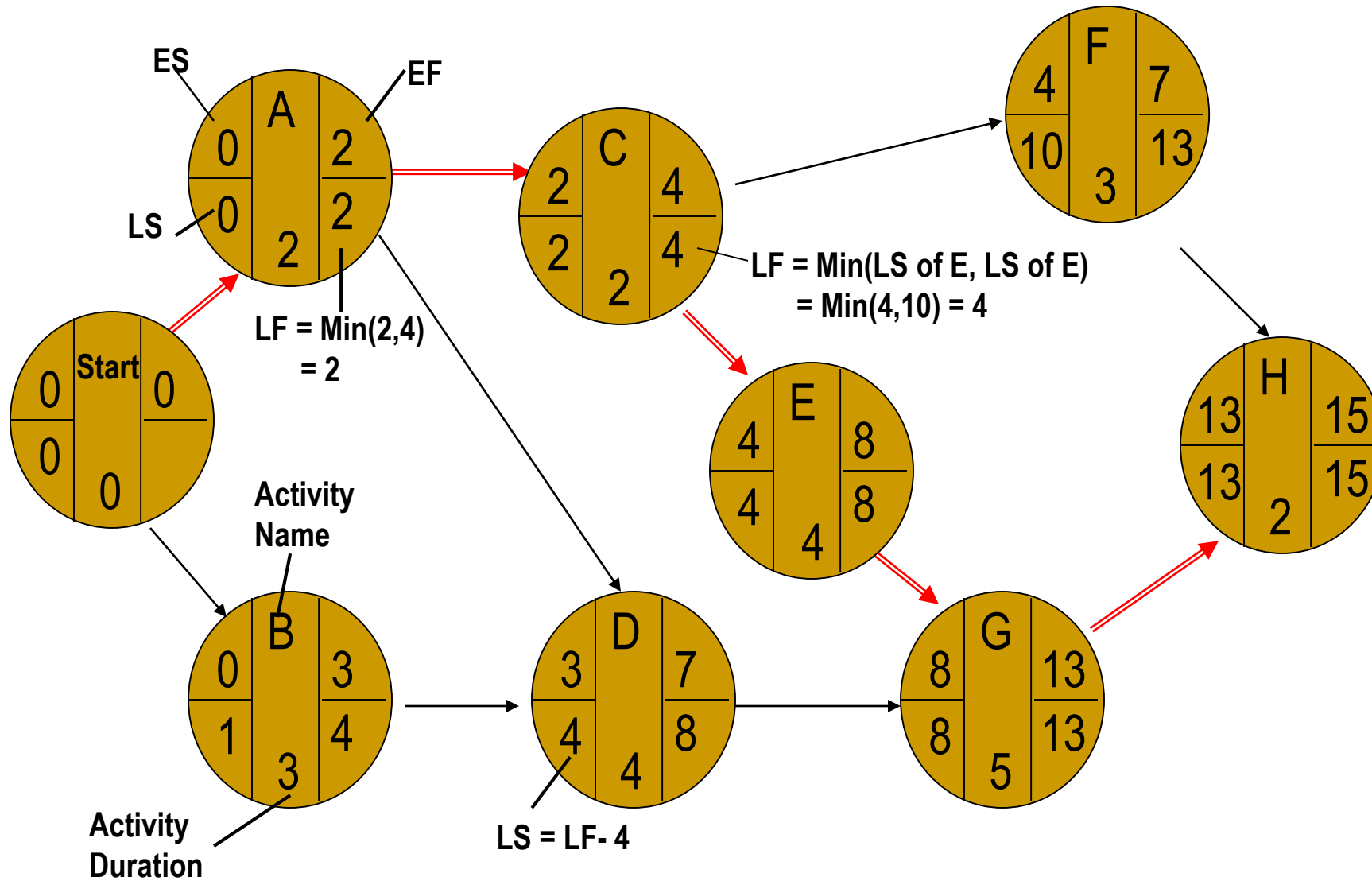
Activity	Immediate Predecessors	Duration (week)
A	-	2
B	-	3
C	A	2
D	A, B	4
E	C	4
F	C	3
G	D, E	5
H	F, G	2



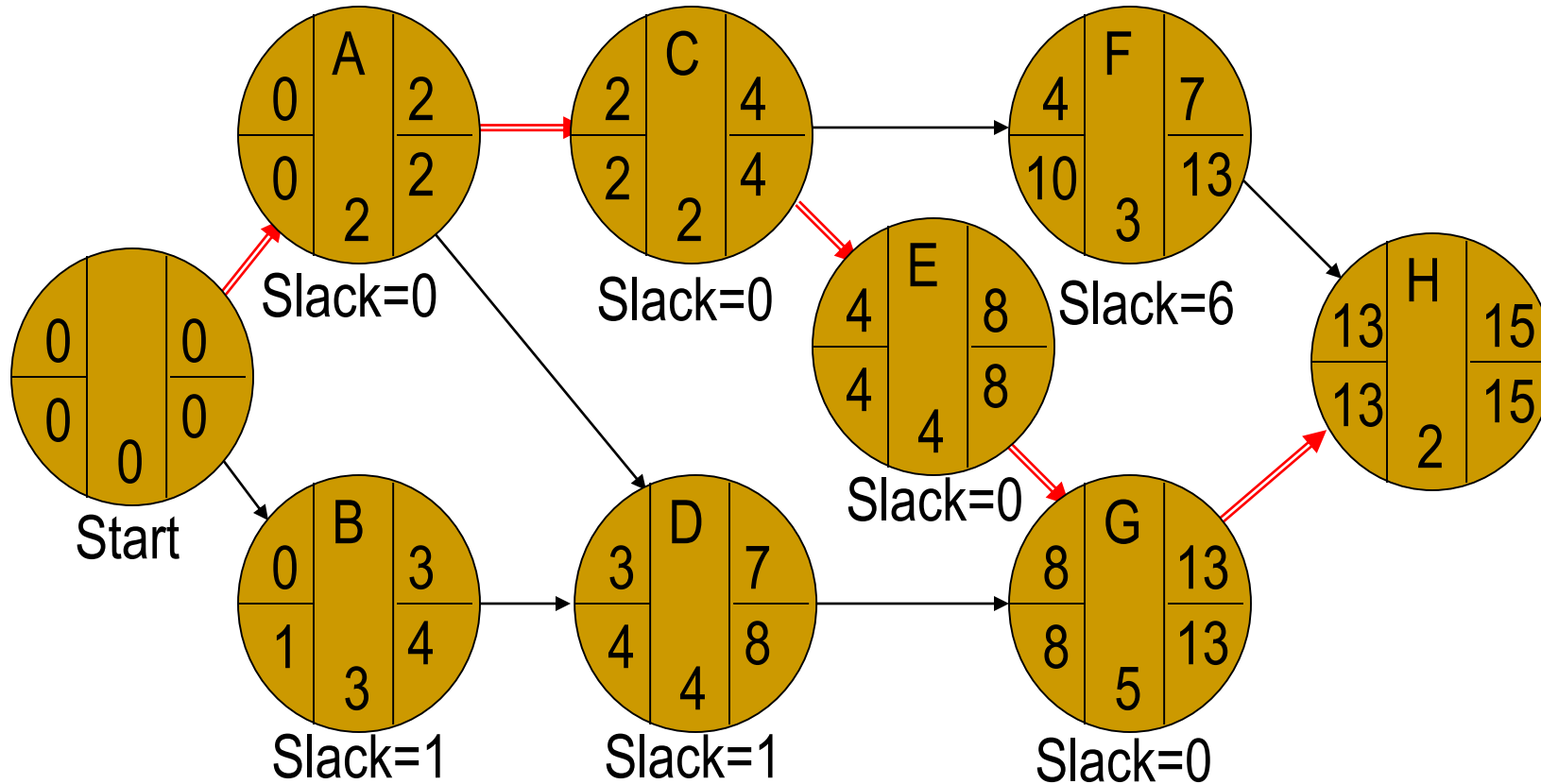
Earliest Start and Earliest Finish Times



Latest Start and Latest Finish Times



Critical Path and Slack Time



Slack Time

Activity	ES	EF	LS	LF	Slack LS-ES	On Critical Path
A	0	2	0	2	0	Y
B	0	3	1	4	1	N
C	2	4	2	4	0	Y
D	3	7	4	8	1	N
E	4	8	4	8	0	Y
F	4	7	10	13	6	N
G	8	13	8	13	0	Y
H	13	15	13	15	0	Y

Buffers and Critical Chain

- A **buffer** is additional time to complete a task.
- **Murphy's Law** states that if something can go wrong, it will.
- **Parkinson's Law** states that work expands to fill the time allowed.
- In traditional estimates, people often add a buffer to each task and use the additional time whether it's needed or not.
- Critical chain scheduling removes buffers from individual tasks and instead creates:
 - A **project buffer** or additional time added before the project's due date.
 - **Feeding buffers** or additional time added before tasks on the critical path, located every place a non-Critical Chain task feeds a Critical Chain task.

Example

KOLL BUSINESS CENTER County Engineers Design Department		
Activity	Description	Preceding Activity
A	Application approval	None
B	Construction plans	A
C	Traffic study	A
D	Service availability check	A
E	Staff report	B, C
F	Commission approval	B, C, D
G	Wait for construction	F
H	Occupancy	E, G

Program Evaluation and Review Technique (PERT)

- PERT is a network analysis technique used to estimate project duration when there is a high degree of uncertainty about the individual activity duration estimates.
- PERT uses **probabilistic time estimates**:
 - Duration estimates based on using optimistic, most likely, and pessimistic estimates of activity durations, or a three-point estimate.

PERT Formula and Example

- PERT weighted average =

$$\frac{\text{optimistic time} + 4 \times \text{most likely time} + \text{pessimistic time}}{6}$$

- Example:

PERT weighted average =

$$\frac{8 \text{ workdays} + 4 \times 10 \text{ workdays} + 24 \text{ workdays}}{6} = \mathbf{12 \text{ days}}$$

where:

optimistic time = 8 days

most likely time = **10 days**

pessimistic time = 24 days

Therefore, you'd use **12 days** on the network diagram instead of 10 when using PERT for the above example.

Probabilistic Activity Times

- These provide an estimate of the mean and variance of a beta distribution:
- mean (expected time):

$$t = \frac{a + 4m + b}{6}$$

- variance

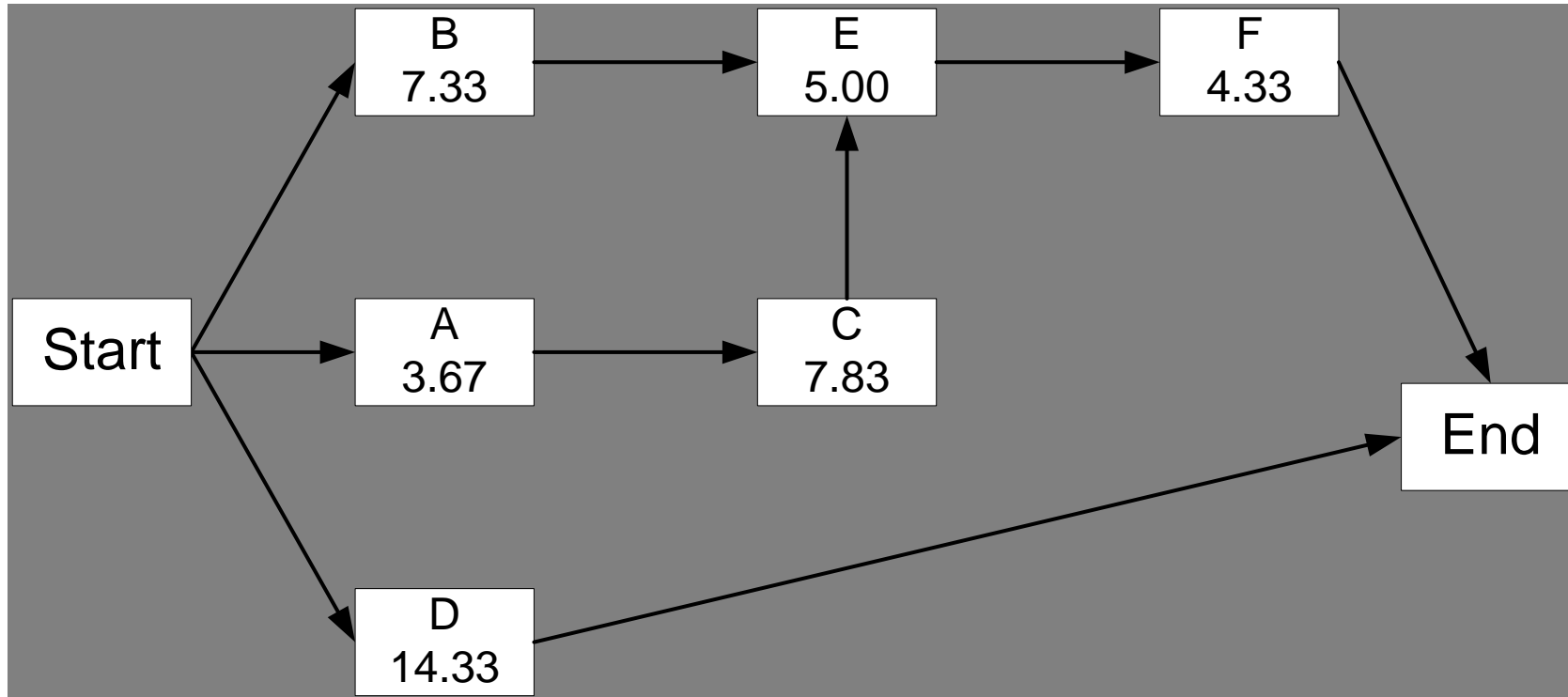
$$v = \left(\frac{b - a}{6} \right)^2$$

- Standard deviation $\sigma = \sqrt{V}$

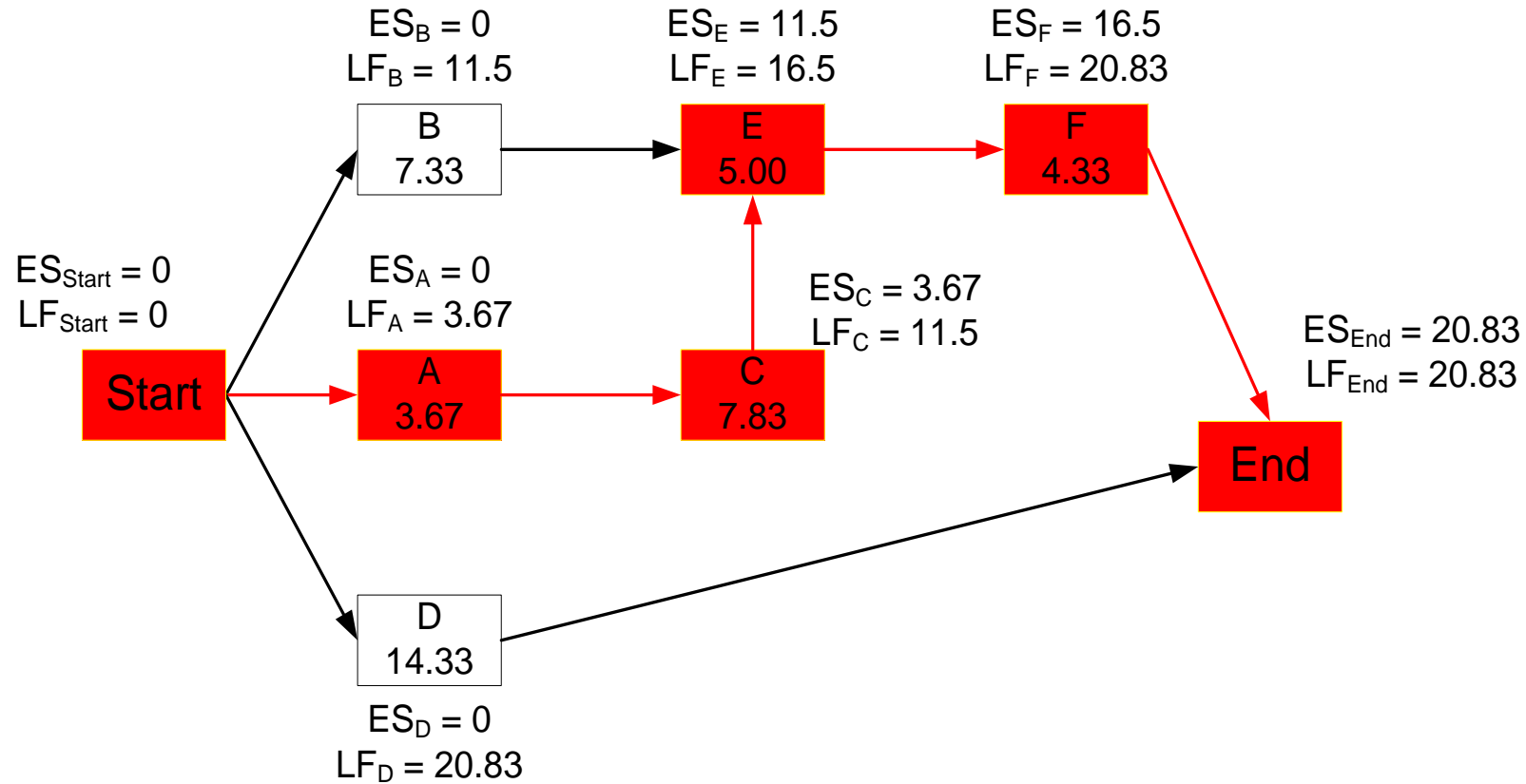
Example

Activities	Predecessor sors	Duration Estimation (weeks)			Expected Duration	Varian- ce
		Optimistic	Likely	Pessimistic		
A	-	2	6	14	3.67	4.00
B	A	4	7	12	7.33	1.78
C	A	2	8	13	7.83	3.36
D	A	12	14	18	14.33	1.00
E	B, C	3	5	7	5.00	0.44
F	E	3	4	7	4.33	0.44

Example : Network



Example : Critical Path



Example

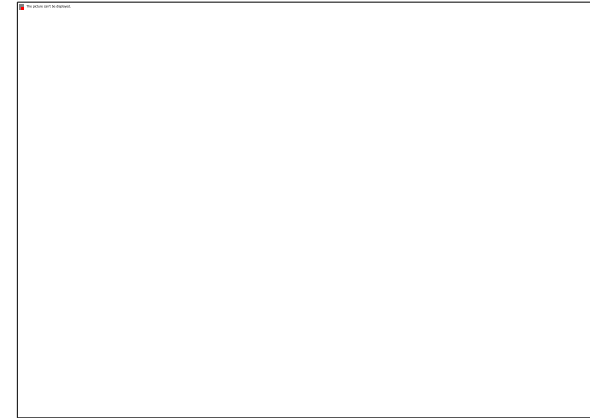
- Expected duration of this project
$$= 3.67 + 7.83 + 5.00 + 4.33 = 20.83$$
- Variance $= 4.00 + 3.36 + 0.44 + 0.44$
$$= 8.25$$
- Standard deviation $(\sigma) = 2.87$

Question from the Example?

- What is the probability that the project will be completed with in 25 weeks?

$$Z = \frac{x - \bar{x}}{\sigma} = \frac{25 - 20.83}{2.87} = 1.45$$

- Probability = 92.7 %

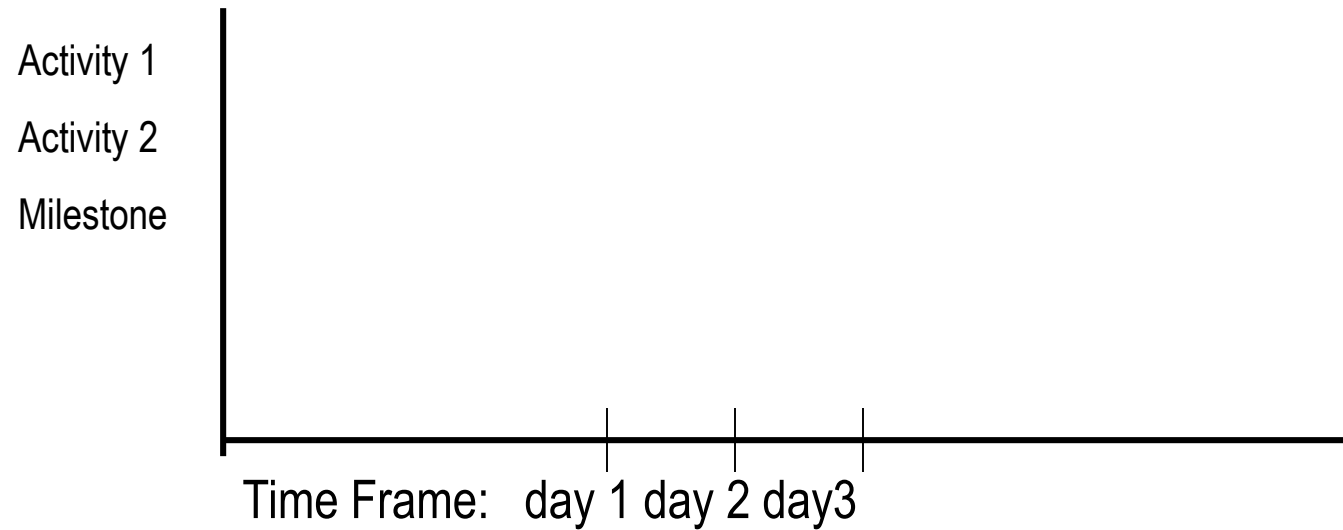


Gantt Chart

- Visual scheduling tool
- Graphical representation of information
- Show dependencies between tasks, personnel, and other resources allocations
- Track progress towards completion

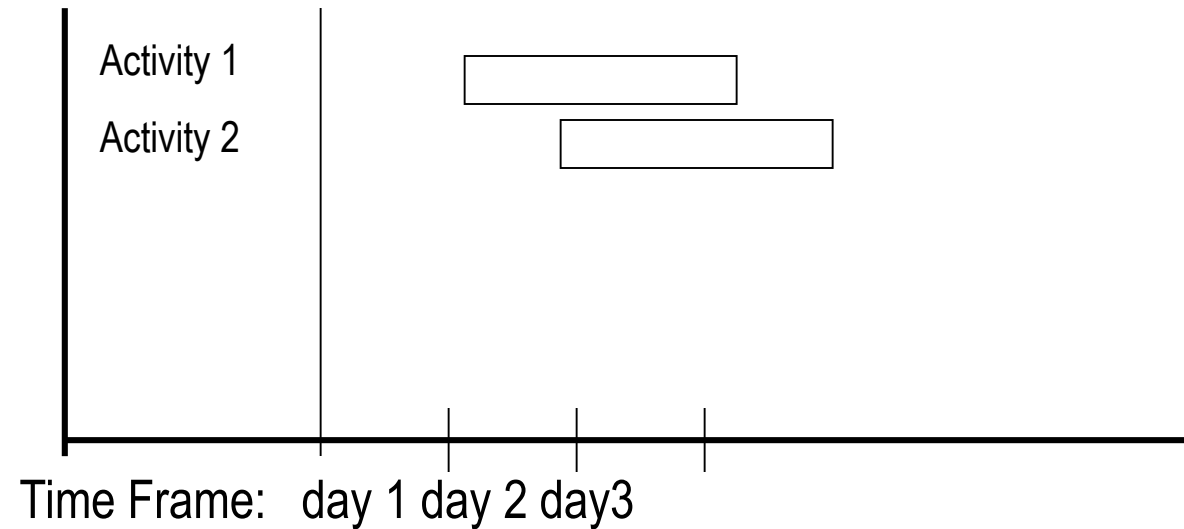
Building Gantt Chart

- List all tasks and milestones from the project along the vertical axis
- List time frame along the horizontal axis



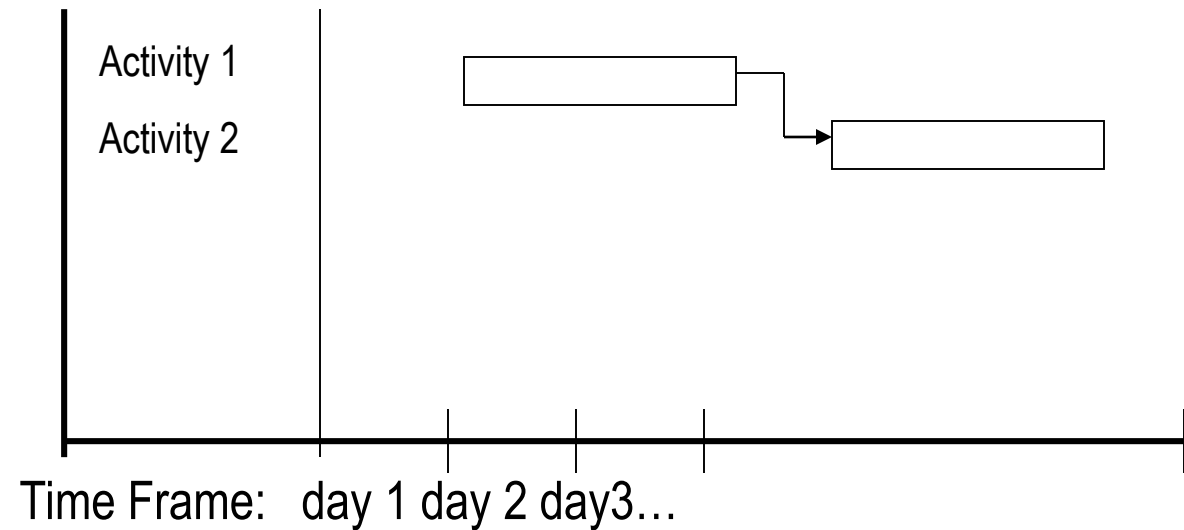
Building Gantt Chart

- Activities: Create box the length of each activity time duration
 - E.g., activity one is scheduled from day1-day3



Building Gantt Chart

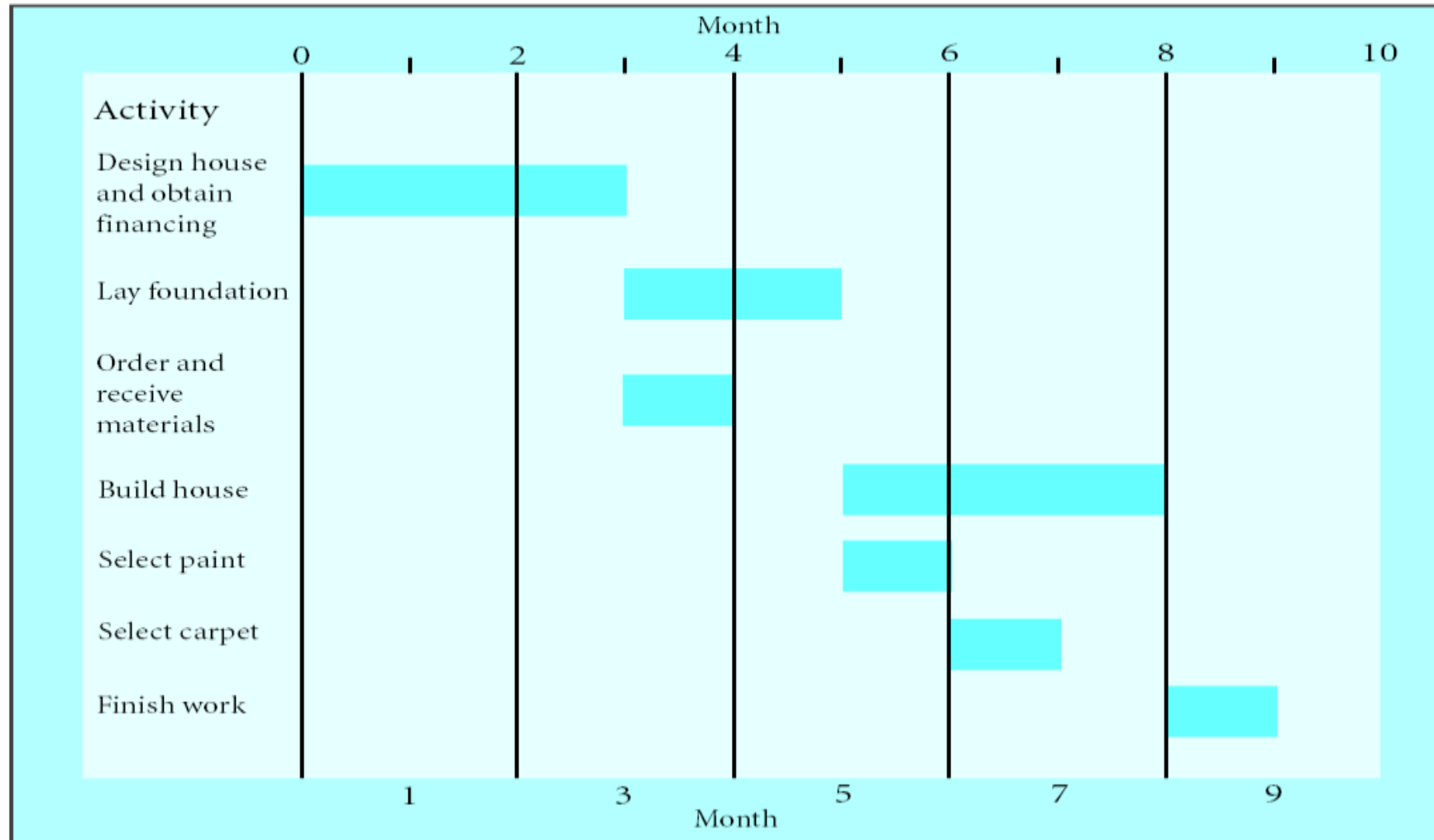
- Dependencies: Show dependencies between activities with arrows
 - E.g., activity 2 cannot start until activity 1 is complete



Sequence of Activities of The Project - House Building

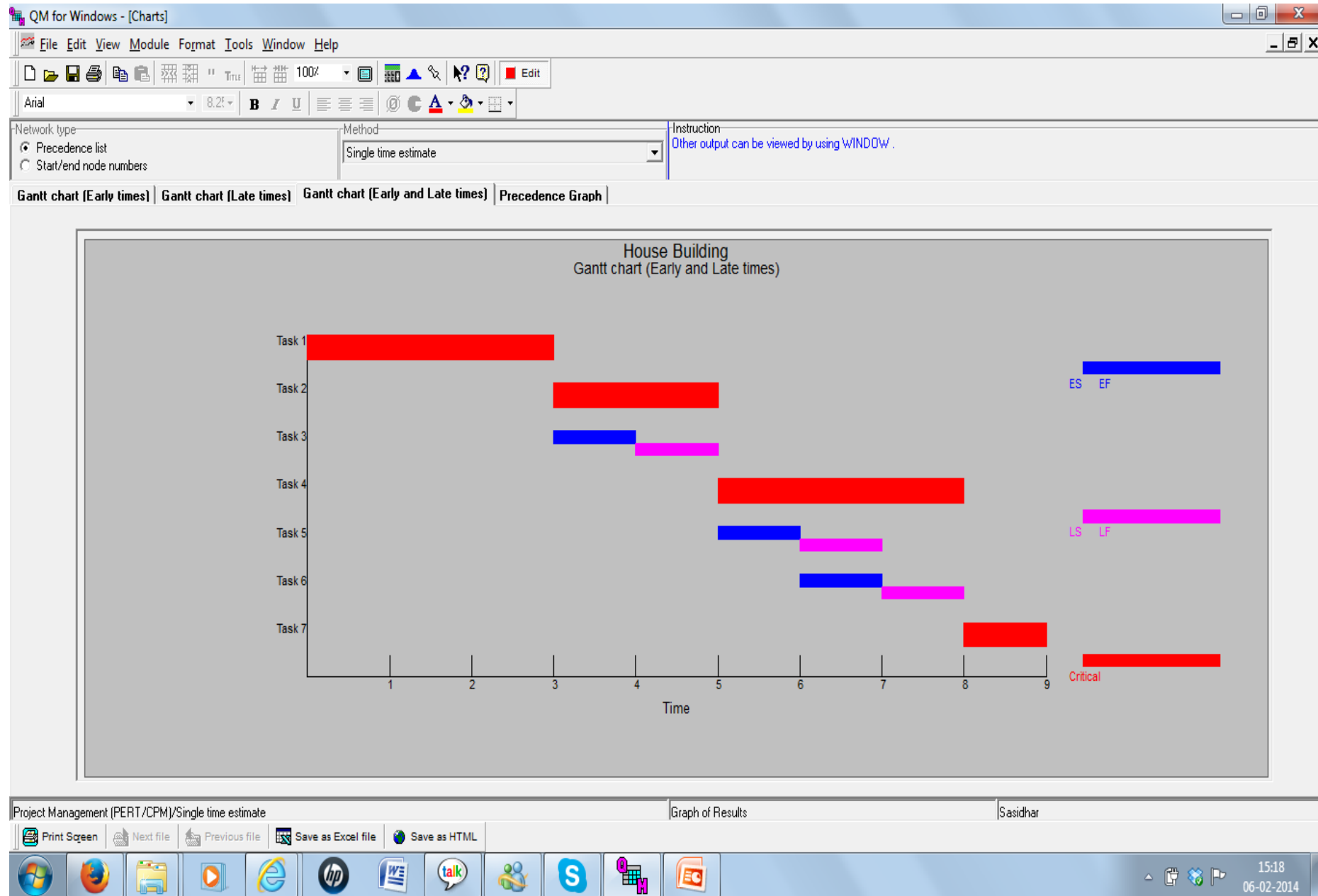
Number	Activity	Predecessor	Duration
1	Design house and obtain financing	--	3 months
2	Lay foundation	1	2 months
3	Order and receive materials	1	1 month
4	Build house	2,3	3 months
5	Select paint	2, 3	1 month
6	Select carper	5	1 month
7	Finish work	4, 6	1 month

Gantt Chart for House Building Project



A Gantt chart

Gantt Chart for House Building Project using QM for Windows



Gantt Charts

- ✓ Establish a *time-phased network*
- ✓ Can be used as a *tracking tool*

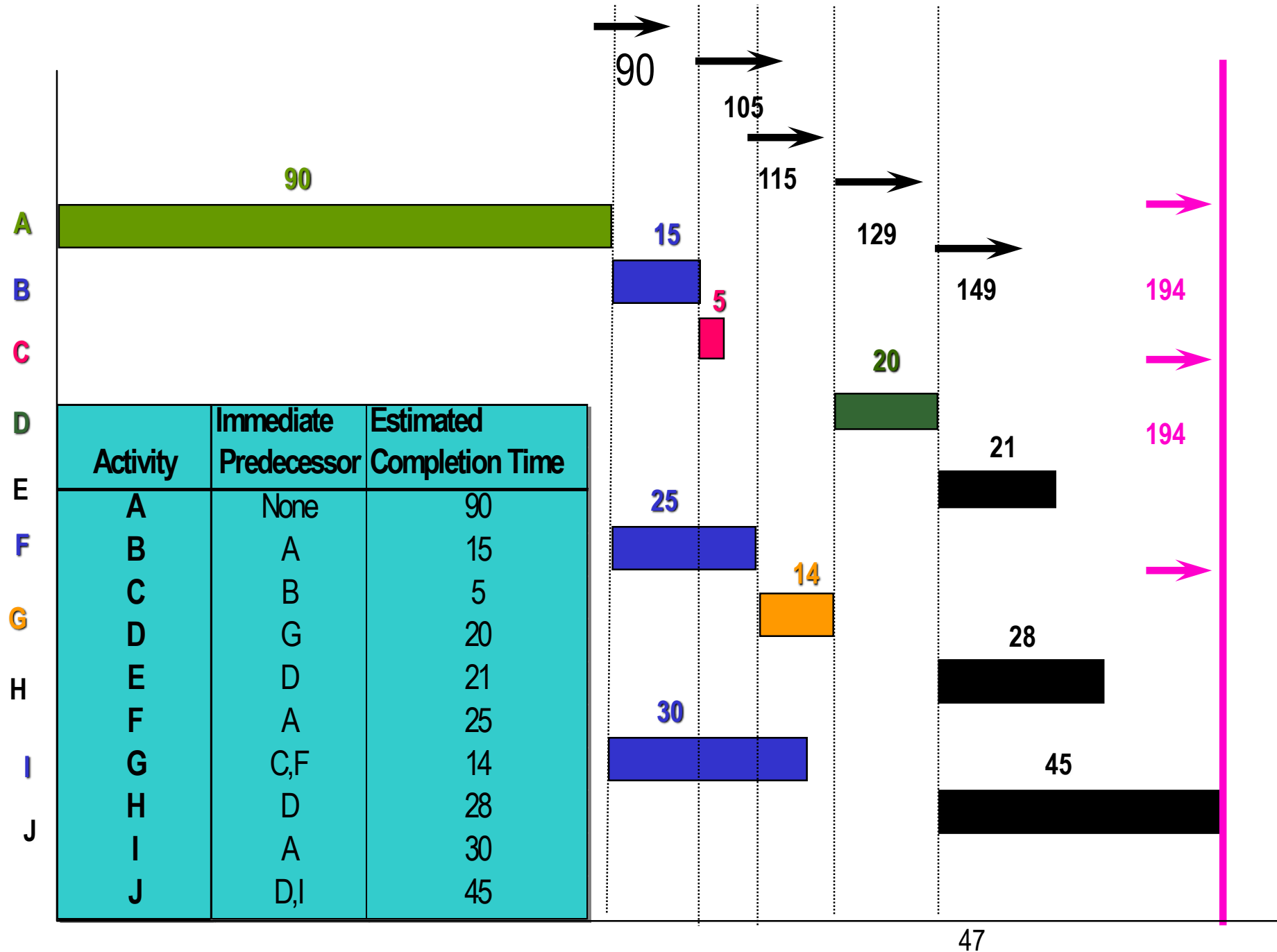
Benefits of Gantt charts

1. Easy to *create* and *comprehend*
2. Identify the schedule *baseline* network
3. Allow for *updating* and *control*
4. Identify *resource needs*

Example

Precedence Relationships Chart

Activity	Immediate Predecessor	Estimated Completion Time
A	None	90
B	A	15
C	B	5
D	G	20
E	D	21
F	A	25
G	C,F	14
H	D	28
I	A	30
J	D,I	45



Comparison of Gantt Charts and Network Diagrams

- Gantt Charts
 - Visually shows duration of tasks
 - Visually shows time overlap between tasks
 - Visually shows slack time
- Network Diagrams
 - Visually shows dependencies between tasks
 - Visually shows which tasks can be done in parallel
 - Shows slack time by data in rectangles

Gantt Chart and Network Diagram for Pine Valley Furniture

- Steps
 1. Identify each activity
 - Requirements Collection
 - Screen Design
 - Report Design
 - Database Design
 - User documentation
 - Software programming
 - Installation and testing

Gantt Chart and Network Diagram for Pine Valley Furniture

2. Determine time estimates and expected completion times for each activity.

Figure 2.20 Estimated Time Calculations for the SPTS Project

ACTIVITY	TIME ESTIMATE (in weeks)			EXPECTED TIME (ET) $\frac{o + 4r + p}{6}$
	<i>o</i>	<i>r</i>	<i>p</i>	
1. Requirements Collection	1	5	9	5
2. Screen Design	5	6	7	6
3. Report Design	3	6	9	6
4. Database Design	1	2	3	2
5. User Documentation	3	6	7	5.5
6. Programming	4	5	6	5
7. Testing	1	3	5	3
8. Installation	1	1	1	1

Gantt Chart and Network Diagram for Pine Valley Furniture

3. Determine sequence of activities

Figure 2.21 Sequence of Activities within the SPTS Project

ACTIVITY	PRECEDING ACTIVITY
1. Requirements Collection	—
2. Screen Design	1
3. Report Design	1
4. Database Design	2,3
5. User Documentation	4
6. Programming	4
7. Testing	6
8. Installation	5,7

Gantt Chart and Network Diagram for Pine Valley Furniture

4. Determine critical path
 - Sequence of events that will affect the final project delivery date

Figure 2.23 A Network Diagram That Illustrates the Activities (Circles) and the Sequence (Arrows) of Those Activities

